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USGS External Grants 02HQGR0034 (Nelson) and (Goldfinger)

TITLE: HOLOCENE SEISMICITY OF THE NORTHERN SAN ANDREAS FAULT BASED ON PRECISE DATING OF THE TURBIDITE EVENT RECORD.COLLABORATIVE RESEARCH WITH OREGON STATE UNIVERSITY AND GRANADA UNIVERSITY.

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ABSTRACT

Unlike Cascadia, the northern California margin does not appear to have a regional stratigraphic datum, thus correlating events and testing for an earthquake origin will depend more heavily on stratigraphic correlation, tests of synchroneity, and possibly other methods of distinguishing earthquake triggered turbidite deposits from those triggered by other mechanisms. Preliminary mineralogic data suggest a synchronous origin for at least some of the events examined thus far. We have been able to distinguish three mineralogic provenances in the cores, well linked to the onshore source geology. Channels from these distinct provenances come together at confluences, below which we see mixed provenance. Rather than separate events from each provenance, we see either doublets, with no hemipelagic sediment between the events, or bimodal coarse fractions in the turbidites, each peak representing a separate provenance. Since the coarse fractions of turbidites settle out in minutes to hours, the couplets and bimodal distributions indicate little or no time passage during deposition. Synchronous deposition in turn suggests a synchronous timing of the triggering of the source events. Few, if any, triggering events other than earthquakes can satisfy the very short time requirements for synchronous initiation of turbidity currents separated by large distances along the margin.

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FY 2002 Investigations Undertaken

The objective of this project is to test the hypothesis that turbidites deposited in these channels resulted from turbid flows triggered by earthquakes on the northern San Andreas fault. Previous work on the Cascadia margin has shown that turbidites there were most likely the exclusive result of earthquake triggering of turbid flows. Along the north coast of California, the northern segment of the San Andreas lies close to the coast or just offshore between San Francisco and Point Delgada. Favorable physiography of both fault and channel systems suggested that the northern San Andreas might be a good locality to test the methods and hypotheses previously applied to Cascadia.

During 2002 we completed planning for our NSF/USGS sponsored cruise aboard the R/V Roger Revelle in June-July 2002. A myriad of tasks to prepare for this cruise both scientific and logistical were completed in the first half of 2002. Recruitment of the science party and training students and participants in core logging, core analysis, GIS tasks, and multibeam mapping took place during the spring at OSU. We compiled existing sonar, bathymetric, core, coastal river data and other datasets for incorporation into out GIS for the San Andreas fault. We installed and tested a new digital line-scan camera attachment for the GeoTek Multi-track logger which was used for the first time on our cruise, producing exceptionally high-resolution registered imagery of the cores. This is critical, since some of the cores will be essentially destroyed by sampling for radiocarbon ages. Finally, we constructed a new jumbo Kasten corer specifically for sampling turbidite sequences. This corer is both large volume (400 cm^2 in section) and very robust, built of 1/4" plate with a 5000 lb weight stand.

During June and July, 2002, we collected 69 piston, gravity and Kasten cores from channel and canyon systems draining the northern California margin on the Scripps R/V Revelle. We operated 24hours a day for 30 days with an international science party of 37 scientists and students from the US, Russia, England, France, Belgium, Germany and Spain. We also mapped channel systems with the new Simrad EM-120 multibeam sonar. This system provides both high-resolution bathymetry and backscatter data. During the cruise, we sampled all major and many minor channel systems extending from Cape Mendocino to just north of Monterey Bay. Sampling both down and across channels in some cases was done, and particular attention was paid to channel confluences, as these areas afford opportunities to test for synchronous triggering of turbid flows.

While at sea, all cores were run therough the OSU multisensor track core logger (mst) which collects p-wave velocity, gamma ray density, and magnetic susceptibility from the unsplit cores. Cores were then split, and run through the mst again to collect high-resolution line-scan imagery. After the mst runs, cores were sampled with a high-resolution magnetic susceptibility probe at 1cm intervals, then were hand logged by sedimentologists. Samples for micropaleontology were taken and analyzed in real-time, providing a rapid determination of how deep into the Holocene or Pleistocene each core had penetrated. Simultaneously, samples were taken for mineralogy, and were analyzed for heavy minerals at sea to attempt to distinguish channels systems by their mineralogic characteristics. Overall, the cruise was highly successful. With a large and talented

science party, we were able to emulate and Ocean Drilling Program cruise, and complete all the physical property work and core logging while at sea.

FY 2002 Results

Unlike Cascadia, the Northern California margin does not appear to have a regional stratigraphic datum, thus correlating events and testing for an earthquake origin will depend more heavily on stratigraphic correlation, tests of synchroneity, and possibly other methods of distinguishing earthquake triggered turbidite deposits from those triggered by other mechanisms. Preliminary mineralogic data suggest a synchronous origin for at least some of the events examined thus far. We have been able to distinguish three mineralogic provenances in the cores, well linked to the onshore source geology. Channels from these distinct provenances come together at confluences, below which we see mixed provenance. Rather than separate events from each provenance, we see either doublets, with no hemipelagic sediment between the events, or bimodal coarse fractions in the turbidites, each peak representing a separate provenance. Since the coarse fractions of turbidites settle out in minutes to hours, the couplets and bimodal distributions indicate little or no time passage during deposition (alternately, a somewhat convenient degree of basal erosion of the upper event could create the same stratigraphy). Synchronous deposition in turn suggests a synchronous timing of the triggering of the source events. Few, if any, triggering events other than earthquakes can satisfy the very short time requirements for synchronous initiation of turbidity currents separated by large distances along the margin. A second possible "synchronous" origin might include storm generated flows, which could conceivably produce flows in separate canyons that were triggered within hours of each other. However, channel systems in northern California, like Cascadia, are mostly separated from river systems in the coastal mountains by a broad continental shelf. On the Washington margin, storm surges are generally swept to the north by the Davidson current during the winter months in which they occur, and these deposits mostly do not reach the canyon heads directly. The same current prevails off northern California, and we suggest that for the most part, like Washington, storm surges are not directly injected into the canyon systems to the west. Our preliminary investigations thus suggest that at least some of the events observed in our initial look at these cores are probably earthquake triggered.

Shore-based analysis of the cores and data has continued through 2002. We have now x-rayed about 50% of the cores, and completed a more detailed micropaleontologic stratigraphy for all cores. We have completed color reflectance analysis of the cores using the high-resolution imagery from the Geotek system, and integrated these data with digital core logs. We are beginning a detailed petrologic analysis of the sand fraction of the turbidites, focusing on heavy mineral assemblages. Thus far, we are very encouraged by the preliminary results. Within the three major mineralogic provinces were we able to distinguish at sea, we were concerned that we would have difficulty distinguishing between adjacent channel systems within the same province. The heavy mineral data however shows that we can reliably distinguish between the channels that should be the most alike, based on consistent differences in the heavy minerals. These differences are maintained down core and down channel, and thus are proving to be robust fingerprints of each system. There is no certainty that this will be true for all channels, but thus

far, we are encouraged by the consistency of these data. Another method we are testing for correlation is the high-resolution magnetic susceptibility data. We first began to correlate events down channel using these data, and found that much like electric log data in wells, the magnetic data showed that each event downchannel had a distinctive "signature" wiggle pattern in the data that persisted from core to core. What surprises us is that this distinctive wiggle pattern not only persists down channels, but along the margin from one channel to another. In many cases, we have made preliminary correlations based on "wiggle matching" that extend along much of the continental slope in the study area. Given that individual turbid flows in separate canyons with different sediment supply, bathymetry, configuration and other parameters have little in common, it's difficult to understand why these wiggle traces in the magnetic data would look as similar as they do. However the striking similarity of these plots is leading us to investigate these correlations and possible origins.

Non-Technical Summary

Cores from the Noyo Channel on the ocean floor off northern California have been examined for sand layers. These sand layers are thought to represent times when great earthquakes on the northern San Andres fault have shaken the continental margin, resulting in landslides that transport the sand down the channels. Many cores have been taken in other sea-floor channels to verify this preliminary record of earthquakes. Therefore, we have developed a scientific cruise funded from National Science Foundation in July, 2002 to collect these new cores and verify the history of earthquakes.

Published Results

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Availability of Data

The calculated parameters are in Excell data tables, plots and Word documents at University of Granada and OSU. All processed AMS radiocarbon age data is available in Excell data tables. Analogue records of core lithologic data are archived at OSU core repository where the cores are stored. Additional interpretative data of core logs are available in Adobe Illustrator files that reside at both OSU and University of Granada. The general GIS data base of swath bathymetry, seismic profiles, core locations etc. resides at OSU. The contacts for all aforementioned data sets are Hans Nelson (hansnelsonugr@hotmail.com), Chris Goldfinger (gold@oce.orst.edu) and Julia Gutierrez Pastor (juliagpastor@yahoo.es).